Data Appendix for "Uncertainty and Business Cycles: Exogenous Impulse or Endogenous Response?"

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1 Large Datasets

The first dataset, denoted X^m, is an updated version of the of the 132 mostly macroeconomic series used in Ludvigson and Ng (2010). These data are taken from the FRED-MD monthly database (McCracken and Ng (2016)). The macro series in X^m are selected to represent broad categories of macroeconomic time series: real output and income, employment and hours, real retail, manufacturing and trade sales, consumer spending, housing starts, inventories and inventory sales ratios, orders and unfilled orders, compensation and labor costs, capacity utilization measures, price indexes, bond and stock market indexes, and foreign exchange measures. Please see McCracken and Ng (2016) for a detailed description of these series.

The 147 financial series in X^f consists of a number of indicators measuring the behavior of a broad cross-section of asset returns, as well as some aggregate financial indicators not included in the macro dataset. These data include valuation ratios such as the dividend-price ratio and earnings-price ratio, growth rates of aggregate dividends and prices, default and term spreads, yields on corporate bonds of different ratings grades, yields on Treasuries and yield spreads, and a broad cross-section of industry equity returns. Following Fama and French (1992), returns on 100 portfolios of equities sorted into 10 size and 10 book-market categories. The dataset X^f also includes a group of variables we call "risk-factors," since they have been used in cross-sectional or time-series studies to uncover variation in the market risk-premium. These risk-factors include the three Fama and French (1993) risk factors, namely the excess return on the market MKT_t, the "small-minus-big" (SMB_t) and "high-minus-low" (HML_t) portfolio returns, the momentum factor UMD_t, the bond risk premia factor of Cochrane and Piazzesi (2005), and the small stock value spread $R15 - R11$.

The raw data used to form factors are always transformed to achieve stationarity. In addition, when forming forecasting factors from the large macro and financial datasets, the raw data (which are in different units) are standardized before performing PCA. When forming common uncertainty from estimates of individual uncertainty, the raw data (which are in this case in the same units) are demeaned, but we do not divide by the observation's standard deviation before performing PCA.

Throughout, the factors are estimated by the method of static principal components (PCA). Specifically, the $T \times r_F$ matrix $\hat{F}_t$ is $\sqrt{T}$ times the r_F eigenvectors corresponding to the r_F largest eigenvalues of the $T \times T$ matrix $xx'/(TN)$ in decreasing order. In large samples (when $\sqrt{T}/N \to \infty$), Bai and Ng (2006) show that the estimates $\hat{F}_t$ can be treated as though they were observed in the subsequent forecasting regression. There is no need to correct standard errors for uncertainty in this estimate, unlike the generated regressor case analyzed in Pagan (1984) when N is fixed. This asymptotic result allows for time variation in the volatility of the forecast error.

1.1 Macro Dataset

The macro dataset is the FRED-MD monthly database (McCracken and Ng (2016)). Please see http://www.columbia.edu/~sn2294/papers/freddata.pdf for a detailed description.

1.2 Financial Dataset

The data set is at monthly frequency, with 147 observations spanning the period 1960:01-2014:12. All returns and spreads are expressed in logs (i.e. the log of the gross return or spread), are displayed in percent (i.e. multiplied by 100), and are annualized by multiplying by 12, i.e., if x is the original return or spread, we transform to $1200 \ln(1 + x/100)$. Federal Reserve data are annualized by default and are therefore not "re-annualized." Note: this annualization means that the annualized standard deviation (volatility) is equal to the data standard deviation divided by $\sqrt{12}$. The data series used in this dataset are listed below by data source. Additional details on data transformations are given below the table.

Let X_{it} denote variable i observed at time t after e.g., logarithm and differencing transformation, and let X_{it}^A be the actual (untransformed) series. Let $\Delta = (1 - L)$ with $LX_{it} = X_{it-1}$. There are six possible transformations with the following codes:

1 Code lv: $X_{it} = X_{it}^A$.

2 Code Δlv: $X_{it} = X_{it}^A - X_{it-1}^A$.

3 Code $\Delta^2 lv$: $X_{it} = \Delta^2 X_{it}^A$.

4 Code ln: $X_{it} = ln(X_{it}^A)$.

5 Code Δln: $X_{it} = ln(X_{it}^A) - ln(X_{it-1}^A)$.

6 Code $\Delta^2 ln$: $X_{it} = \Delta^2 ln X_{it}^A$.

7 Code $\Delta lv/lv$: $\left(X_{it}^A - X_{it-1}^A\right)/X_{it-1}^A$

No.	Short Name	Source	Tran	Description
1	D_log(DIV)	CRSP	Δln	$\Delta \log D_t^*$ see additional details below
2	D_log(P)	CRSP	Δln	$\Delta \log P_t$ see additional details below
3	D_DIVreinvest	CRSP	Δln	$\Delta \log D_t^{re,*}$ see additional details below
4	D_Preinvest	CRSP	Δln	$\Delta \log P_t^{re,*}$ see additional details below
5	d-p	CRSP	ln	$\log(D_t^*) - \log P_t$ see additional details below
6	R15-R11	Kenneth French	lv	(Small, High) minus (Small, Low) sorted on (size, book-to-market)
7	CP	Monika Piazzesi	lv	Cochrane-Piazzesi factor (Cochrane and Piazzesi (2005))
8	Mkt-RF	Kenneth French	lv	Market excess return
9	SMB	Kenneth French	lv	Small Minus Big, sorted on size
10	HML	Kenneth French	lv	High Minus Low, sorted on book-to-market
11	UMD	Kenneth French	lv	Up Minus Down, sorted on momentum
12	Agric	Kenneth French	lv	Agric industry portfolio
13	Food	Kenneth French	lv	Food industry portfolio
14	Beer	Kenneth French	lv	Beer industry portfolio
15	Smoke	Kenneth French	lv	Smoke industry portfolio
16	Toys	Kenneth French	lv	Toys industry portfolio
17	Fun	Kenneth French	lv	Fun industry portfolio
18	Books	Kenneth French	lv	Books industry portfolio
19	Hshld	Kenneth French	lv	Hshld industry portfolio
20	Clths	Kenneth French	lv	Clths industry portfolio
21	MedEq	Kenneth French	lv	MedEq industry portfolio
22	Drugs	Kenneth French	lv	Drugs industry portfolio
23	Chems	Kenneth French	lv	Chems industry portfolio
24	Rubbr	Kenneth French	lv	Rubbr industry portfolio
25	Txtls	Kenneth French	lv	Txtls industry portfolio
26	BldMt	Kenneth French	lv	BldMt industry portfolio
27	Cnstr	Kenneth French	lv	Cnstr industry portfolio
28	Steel	Kenneth French	lv	Steel industry portfolio
39	Mach	Kenneth French	lv	Mach industry portfolio
30	ElcEq	Kenneth French	lv	ElcEq industry portfolio
31	Autos	Kenneth French	lv	Autos industry portfolio
32	Aero	Kenneth French	lv	Aero industry portfolio
33	Ships	Kenneth French	lv	Ships industry portfolio
34	Mines	Kenneth French	lv	Mines industry portfolio
35	Coal	Kenneth French	lv	Coal industry portfolio
36	Oil	Kenneth French	lv	Oil industry portfolio
37	Util	Kenneth French	lv	Util industry portfolio
38	Telcm	Kenneth French	lv	Telcm industry portfolio
39	PerSv	Kenneth French	lv	PerSv industry portfolio
40	BusSv	Kenneth French	lv	BusSv industry portfolio
41	Hardw	Kenneth French	lv	Hardw industry portfolio
42	Chips	Kenneth French	lv	Chips industry portfolio
43	LabEq	Kenneth French	lv	LabEq industry portfolio
44	Paper	Kenneth French	lv	Paper industry portfolio
45	Boxes	Kenneth French	lv	Boxes industry portfolio
46	Trans	Kenneth French	lv	Trans industry portfolio
47	Whlsl	Kenneth French	lv	Whlsl industry portfolio
48	Rtail	Kenneth French	lv	Rtail industry portfolio
49	Meals	Kenneth French	lv	Meals industry portfolio
50	Banks	Kenneth French	lv	Banks industry portfolio
51	Insur	Kenneth French	lv	Insur industry portfolio
52	RlEst	Kenneth French	lv	RlEst industry portfolio
53	Fin	Kenneth French	lv	Fin industry portfolio
54	Other	Kenneth French	lv	Other industry portfolio

List of Financial Dataset Variables (Cont'd)

No.	Short Name	Source	Tran	Description
55	1_2	Kenneth French	*lv*	(1, 2) portfolio sorted on (size, book-to-market)
56	1_4	Kenneth French	*lv*	(1, 4) portfolio sorted on (size, book-to-market)
57	1_5	Kenneth French	*lv*	(1, 5) portfolio sorted on (size, book-to-market)
58	1_6	Kenneth French	*lv*	(1, 6) portfolio sorted on (size, book-to-market)
59	1_7	Kenneth French	*lv*	(1, 7) portfolio sorted on (size, book-to-market)
60	1_8	Kenneth French	*lv*	(1, 8) portfolio sorted on (size, book-to-market)
61	1_9	Kenneth French	*lv*	(1, 9) portfolio sorted on (size, book-to-market)
62	1_high	Kenneth French	*lv*	(1, high) portfolio sorted on (size, book-to-market)
63	2_low	Kenneth French	*lv*	(2, low) portfolio sorted on (size, book-to-market)
64	2_2	Kenneth French	*lv*	(2, 2) portfolio sorted on (size, book-to-market)
65	2_3	Kenneth French	*lv*	(2, 3) portfolio sorted on (size, book-to-market)
66	2_4	Kenneth French	*lv*	(2, 4) portfolio sorted on (size, book-to-market)
67	2_5	Kenneth French	*lv*	(2, 5) portfolio sorted on (size, book-to-market)
68	2_6	Kenneth French	*lv*	(2, 6) portfolio sorted on (size, book-to-market)
69	2_7	Kenneth French	*lv*	(2, 7) portfolio sorted on (size, book-to-market)
70	2_8	Kenneth French	*lv*	(2, 8) portfolio sorted on (size, book-to-market)
71	2_9	Kenneth French	*lv*	(2, 9) portfolio sorted on (size, book-to-market)
72	2_high	Kenneth French	*lv*	(2, high) portfolio sorted on (size, book-to-market)
73	3_low	Kenneth French	*lv*	(3, low) portfolio sorted on (size, book-to-market)
74	3_2	Kenneth French	*lv*	(3, 2) portfolio sorted on (size, book-to-market)
75	3_3	Kenneth French	*lv*	(3, 3) portfolio sorted on (size, book-to-market)
76	3_4	Kenneth French	*lv*	(3, 4) portfolio sorted on (size, book-to-market)
77	3_5	Kenneth French	*lv*	(3, 5) portfolio sorted on (size, book-to-market)
78	3_6	Kenneth French	*lv*	(3, 6) portfolio sorted on (size, book-to-market)
79	3_7	Kenneth French	*lv*	(3, 7) portfolio sorted on (size, book-to-market)
80	3_8	Kenneth French	*lv*	(3, 8) portfolio sorted on (size, book-to-market)
81	3_9	Kenneth French	*lv*	(3, 9) portfolio sorted on (size, book-to-market)
82	3_high	Kenneth French	*lv*	(3, high) portfolio sorted on (size, book-to-market)
83	4_low	Kenneth French	*lv*	(4, low) portfolio sorted on (size, book-to-market)
84	4_2	Kenneth French	*lv*	(4, 2) portfolio sorted on (size, book-to-market)
85	4_3	Kenneth French	*lv*	(4, 3) portfolio sorted on (size, book-to-market)
86	4_4	Kenneth French	*lv*	(4, 4) portfolio sorted on (size, book-to-market)
87	4_5	Kenneth French	*lv*	(4, 5) portfolio sorted on (size, book-to-market)
88	4_6	Kenneth French	*lv*	(4, 6) portfolio sorted on (size, book-to-market)
89	4_7	Kenneth French	*lv*	(4, 7) portfolio sorted on (size, book-to-market)
90	4_8	Kenneth French	*lv*	(4, 8) portfolio sorted on (size, book-to-market)
91	4_9	Kenneth French	*lv*	(4, 9) portfolio sorted on (size, book-to-market)
92	4_high	Kenneth French	*lv*	(4, high) portfolio sorted on (size, book-to-market)
93	5_low	Kenneth French	*lv*	(5, low) portfolio sorted on (size, book-to-market)
94	5_2	Kenneth French	*lv*	(5, 2) portfolio sorted on (size, book-to-market)
95	5_3	Kenneth French	*lv*	(5, 3) portfolio sorted on (size, book-to-market)
96	5_4	Kenneth French	*lv*	(5, 4) portfolio sorted on (size, book-to-market)
97	5_5	Kenneth French	*lv*	(5, 5) portfolio sorted on (size, book-to-market)
98	5_6	Kenneth French	*lv*	(5, 6) portfolio sorted on (size, book-to-market)
99	5_7	Kenneth French	*lv*	(5, 7) portfolio sorted on (size, book-to-market)
100	5_8	Kenneth French	*lv*	(5, 8) portfolio sorted on (size, book-to-market)
101	5_9	Kenneth French	*lv*	(5, 9) portfolio sorted on (size, book-to-market)
102	5_high	Kenneth French	*lv*	(5, high) portfolio sorted on (size, book-to-market)

List of Financial Dataset Variables (Continued)

No.	Short Name	Source	Tran	Description
103	6_low	Kenneth French	*lv*	(6, low) portfolio sorted on (size, book-to-market)
104	6_2	Kenneth French	*lv*	(6, 2) portfolio sorted on (size, book-to-market)
105	6_3	Kenneth French	*lv*	(6, 3) portfolio sorted on (size, book-to-market)
106	6_4	Kenneth French	*lv*	(6, 4) portfolio sorted on (size, book-to-market)
107	6_5	Kenneth French	*lv*	(6, 5) portfolio sorted on (size, book-to-market)
108	6_6	Kenneth French	*lv*	(6, 6) portfolio sorted on (size, book-to-market)
109	6_7	Kenneth French	*lv*	(6, 7) portfolio sorted on (size, book-to-market)
110	6_8	Kenneth French	*lv*	(6, 8) portfolio sorted on (size, book-to-market)
111	6_9	Kenneth French	*lv*	(6, 9) portfolio sorted on (size, book-to-market)
112	6_high	Kenneth French	*lv*	(6, high) portfolio sorted on (size, book-to-market)
113	7_low	Kenneth French	*lv*	(7, low) portfolio sorted on (size, book-to-market)
114	7_2	Kenneth French	*lv*	(7, 2) portfolio sorted on (size, book-to-market)
115	7_3	Kenneth French	*lv*	(7, 3) portfolio sorted on (size, book-to-market)
116	7_4	Kenneth French	*lv*	(7, 4) portfolio sorted on (size, book-to-market)
117	7_5	Kenneth French	*lv*	(7, 5) portfolio sorted on (size, book-to-market)
118	7_6	Kenneth French	*lv*	(7, 6) portfolio sorted on (size, book-to-market)
119	7_7	Kenneth French	*lv*	(7, 7) portfolio sorted on (size, book-to-market)
120	7_8	Kenneth French	*lv*	(7, 8) portfolio sorted on (size, book-to-market)
121	7_9	Kenneth French	*lv*	(7, 9) portfolio sorted on (size, book-to-market)
122	8_low	Kenneth French	*lv*	(8, low) portfolio sorted on (size, book-to-market)
123	8_2	Kenneth French	*lv*	(8, 2) portfolio sorted on (size, book-to-market)
124	8_3	Kenneth French	*lv*	(8, 3) portfolio sorted on (size, book-to-market)
125	8_4	Kenneth French	*lv*	(8, 4) portfolio sorted on (size, book-to-market)
126	8_5	Kenneth French	*lv*	(8, 5) portfolio sorted on (size, book-to-market)
127	8_6	Kenneth French	*lv*	(8, 6) portfolio sorted on (size, book-to-market)
128	8_7	Kenneth French	*lv*	(8, 7) portfolio sorted on (size, book-to-market)
129	8_8	Kenneth French	*lv*	(8, 8) portfolio sorted on (size, book-to-market)
130	8_9	Kenneth French	*lv*	(8, 9) portfolio sorted on (size, book-to-market)
131	8_high	Kenneth French	*lv*	(8, high) portfolio sorted on (size, book-to-market)
132	9_low	Kenneth French	*lv*	(9, low) portfolio sorted on (size, book-to-market)
133	9_2	Kenneth French	*lv*	(9, 2) portfolio sorted on (size, book-to-market)
134	9_3	Kenneth French	*lv*	(9, 3) portfolio sorted on (size, book-to-market)
135	9_4	Kenneth French	*lv*	(9, 4) portfolio sorted on (size, book-to-market)
136	9_5	Kenneth French	*lv*	(9, 5) portfolio sorted on (size, book-to-market)
137	9_6	Kenneth French	*lv*	(9, 6) portfolio sorted on (size, book-to-market)
138	9_7	Kenneth French	*lv*	(9, 7) portfolio sorted on (size, book-to-market)
139	9_8	Kenneth French	*lv*	(9, 8) portfolio sorted on (size, book-to-market)
140	9_high	Kenneth French	*lv*	(9, high) portfolio sorted on (size, book-to-market)
141	10_low	Kenneth French	*lv*	(10, low) portfolio sorted on (size, book-to-market)
142	10_2	Kenneth French	*lv*	(10, 2) portfolio sorted on (size, book-to-market)
143	10_3	Kenneth French	*lv*	(10, 3) portfolio sorted on (size, book-to-market)
144	10_4	Kenneth French	*lv*	(10, 4) portfolio sorted on (size, book-to-market)
145	10_5	Kenneth French	*lv*	(10, 5) portfolio sorted on (size, book-to-market)
146	10_6	Kenneth French	*lv*	(10, 6) portfolio sorted on (size, book-to-market)
147	10_7	Kenneth French	*lv*	(10, 7) portfolio sorted on (size, book-to-market)

1.2.1 CRSP Data Details

Value-weighted price and dividend data were obtained from the Center for Research in Security Prices (CRSP). From the Annual Update data, we obtain monthly value-weighted returns series vwretd (with dividends) and vwretx (excluding dividends). These series have the interpretation

$$VWRETD_t = \frac{P_{t+1} + D_{t+1}}{P_t}$$

$$VWRETX_t = \frac{P_{t+1}}{P_t}$$

From these series, a normalized price series P, can be constructed using the recursion

$$P_0 = 1$$
$$P_t = P_{t-1} \cdot VWRETX_t.$$

A dividend series can then be constructed using

$$D_t = P_{t-1}(VWRETD_t - VWRETX_t).$$

In order to remove seasonality of dividend payments from the data, instead of D_t we use the series

$$D_t^* = \frac{1}{12}\sum_{j=0}^{11} D_{t-j}$$

i.e., the moving average over the entire year. For the price and dividend series under "reinvestment," we calculate the price under reinvestment, P_t^{re}, as the normalized value of the market portfolio under reinvestment of dividends, using the recursion

$$P_0^{re} = 1$$
$$P_t^{re} = P_{t-1} \cdot VWRETD_t$$

Similarly, we can define dividends under reinvestment, D_t^{re}, as the total dividend payments on this portfolio (the number of "shares" of which have increased over time) using

$$D_t^{re} = P_{t-1}^{re}(VWRETD_t - VWRETX_t).$$

As before, we can remove seasonality by using

$$D_t^{re,*} = \frac{1}{2}\sum_{j=0}^{11} D_{t-j}^{re}.$$

Five data series are constructed from the CRSP data as follows:

- D_log(DIV): $\Delta \log D_t^*$.
- D_log(P): $\Delta \log P_t$.
- D_DIVreinvest: $\Delta \log D_t^{re,*}$
- D_Preinvest: $\Delta \log P_t^{re,*}$
- d-p: $\log(D_t^*) - \log(P_t)$

1.2.2 Kenneth French Data Details

The following data are obtained from the data library of Kenneth French's Dartmouth website (http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html):

- Fama/French Factors: From this dataset we obtain the data series RF, Mkt-RF, SMB, HML.
- 25 Portolios formed on Size and Book-to-Market (5 x 5): From this dataset we obtain the series R15-R11, which is the spread between the (small, high book-to-market) and (small, low book-to-market) portfolios.
- Momentum Factor (Mom): From this dataset we obtain the series UMD, which is equal to the momentum factor.
- 49 Industry Porfolios: From this dataset we use all value-weighted series, excluding any series that have missing observations from Jan. 1960 on, from which we obtain the series Agric through Other. The omitted series are: Soda, Hlth, FabPr, Guns, Gold, Softw.
- 100 Portfolios formed in Size and Book-to-Market: From this dataset we use all value-weighted series, excluding any series that have missing observations from Jan. 1960 on. This yields variables with the name X_Y where X stands for the index of the size variable (1, 2, ..., 10) and Y stands for the index of the book-to-market variable (Low, 2, 3, ..., 8, 9, High). The omitted series are 1_low, 1_3, 7_high, 9_9, 10_8, 10_9, 10_high.

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